JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES
VOL. IV DECEMBER 4, 1914 No. 20

PHYSICS.—*Measurements on standards of radiation in absolute value.*[1] W. W. COBLENTZ, Bureau of Standards.

One of the chief needs in the measurement of radiant energy is a convenient standard against which the radiometer may be calibrated. The great utility of a seasoned carbon incandescent lamp as a photometric standard is well recognized, and such a lamp has every desideratum of a standard of radiation, when calibrated against a black body as the primary standard of radiation. The object of the present investigation is to establish and maintain a standard of radiation in the form of seasoned incandescent lamps, and to issue to experimenters similar standards of radiation, whereby may be obtained an accurate calibration of their radiometers in absolute value.

The incandescent lamps were standardized by two independent methods which are in agreement within 0.5 per cent. The first method consisted in comparing the radiation from a black body with the radiation from the incandescent lamp, assuming a value for the coefficient (the "Stefan-Boltzmann constant") of total radiation of the black body. For this purpose a thermopile was directed towards the black body, then towards the incandescent lamp. The second method consisted in a direct measurement, in absolute value, of the energy of the incandescent lamp with a modified form of Angström pyrheliometer. This pyrheliometer gave a value ($\sigma = 5.61 \times 10^{-12}$ watt $cm^{-2}$ $deg^{-4}$)

[1] Detailed paper to appear in the Bulletin of the Bureau of Standards.

for the coefficient of total radiation which is close to the value of this constant as determined by various other methods differing widely in character.

The standard of radiation, in terms of these incandescent lamps, may therefore be considered fairly well established—at least sufficiently to fulfill present requirements. In the lamps issued to the public the intensity of the radiant energy per mm.$^2$ at a distance of 2 meters from the lamp is certified, when the lamp is operated on a given current and voltage.

For rough calibrations of radiometers in absolute measure, a sperm candle or a Hefner lamp may be used. For the sperm candle, burning at a mean height, the intensity of the total radiation at a distance of 1 meter from the flame may be taken to be $29 \times 10^{-6}$ g.-cal per cm$^2$ per second. The intensity of the total radiation at a distance of 1 meter from the Hefner lamp *without a diaphragm* may be taken to be $26 \times 10^{-10}$ g-cal per cm$^{-2}$ per second. The paper gives data also for the radiation from the Hefner lamp with a diaphragm, having a definite opening and situated at a definite distance in front of the lamp. The flame standards are unsteady, and unsatisfactory for use in refined radiation measurements.

PHYSICS.—*The emissivity of metals and oxides, II: Measurements with the micropyrometer.* G. K. BURGESS and R. G. WALTENBURG, Bureau of Standards.[1]

The micropyrometer[2] may be used conveniently for the approximate determination of the monochromatic emissivities of metals, oxides, etc., in microscopic quantities at high temperatures. It is possible to determine to 1 per cent the emissivity of a mass of 0.01 mgm. having an area of 0.25 mm.$^2$ and a thickness of 0.005 mm. The determination of the temperature-coefficient of emissivity is readily made, as well as the detection of variation of emissivity with change of state, as at the melting point.

Assuming the emissivity for solid platinum to be 0.33 for red light of wave length $\lambda = 0.65\mu$ and 0.38 for $\lambda = 0.55\mu$, the fol-

[1] Detailed paper to appear in the Bulletin of the Bureau of Standards.

[2] This Journal, **3**: 7. 1912.

lowing among other results have been obtained as shown in the table.

For none of the metals examined was there a marked temperature coefficient in the range 900 to 2000°C. and for the most of them this coefficient is negligible, the monochromatic emissivity usually agreeing also with the value at 20°C. For the white metals the emissivity usually shows very slight or no change at the melting point, but for gold, silver, copper, and uranium there is a marked discontinuity with red light. For palladium, there are anomalies in the behavior of the emissivity in the region of the melting point, in that the value of emissivity proper to the liquid may persist after freezing, constituting an undercooling radiation effect. For platinum the fact that there is a change in emissivity, for $\lambda = 0.65\mu$, on melting would influence the constancy of the Violle standard of light as usually defined in terms of the luminous radiation from platinum at its melting point.

EMISSIVITIES OF METALS AND OXIDES WITH MICROPYROMETER

| Metals | Cu | Ag | Au | Pd | Pt | Ir | Rh | Ni | Co | Fe | Mn | Ti |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $e_{\lambda=0.65\mu}$ solid | 0.10 | 0.04 | 0.14 | 0.33 | 0.33 | 0.30 | 0.29 | 0.36 | 0.36 | 0.37 | 0.59 | 0.63 |
| $e_{\lambda=0.65\mu}$ liquid | 0.15 | 0.07 | 0.22 | 0.37 | 0.38 | | 0.30 | 0.37 | 0.37 | 0.37 | 0.59 | 0.65 |
| $e_{\lambda=0.55\mu}$ solid | 0.38 | 0.35 | 0.38 | 0.38 | 0.38 | | | 0.44 | | | | 0.75 |
| $e_{\lambda=0.55\mu}$ liquid | 0.36 | 0.35 | 0.38 | | | | | 0.46 | | | | 0.75 |

| | Zr | Th | Y | Er | Be | Cb | V | Cr | Mo | W | U | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $e_{\lambda=0.65\mu}$ solid | 0.32 | 0.36 | 0.35 | 0.55 | 0.61 | 0.49 | 0.35 | 0.39 | 0.43 | 0.39 | 0.54 | |
| $e_{\lambda=0.65\mu}$ liquid | 0.30 | 0.40 | 0.35 | 0.38 | 0.61 | 0.40 | 0.32 | 0.39 | 0.40 | | 0.34 | |
| $e_{\lambda=0.55\mu}$ solid | | 0.36 | | | 0.61 | 0.61 | 0.29 | 0.53 | | | 0.77 | |
| $e_{\lambda=0.55\mu}$ liquid | | | | 0.30 | 0.81 | | | | | | | |

| Oxides near F. P.s | NiO | CoO | $Fe_3O_4$ | $Mn_3O_4$ | $TiO_2$ | $ThO_2$ | $Y_2O_3$ | BeO | $CbO_X$ | $V_2O_3$ | $Cr_2O_3$ | $U_3O_8$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $e_{\lambda=0.65\mu}$ solid | 0.89 | 0.77 | 0.63 | | 0.52 | 0.57 | 0.61 | 0.37 | 0.71 | 0.69 | 0.60 | 0.30 |
| $e_{\lambda=0.65\mu}$ liquid | 0.68 | 0.63 | 0.53 | 0.47 | 0.51 | 0.69 | | | | | | 0.31 |

PHYSICS.—*A vibration electrometer.*[1] HARVEY L. CURTIS, Bureau of Standards.

Any alternating current measurement which makes use of a null method requires an instrument which will detect small

[1] To appear in the Bulletin of the Bureau of Standards.

alternating currents or voltages. One of the first instruments used for this purpose was the telephone. This is very sensitive between the frequencies of 500 and 3000 cycles per second, but at frequencies below 500 cycles the sensitiveness decreases rapidly with the frequency, so that it is very insensitive at frequencies below 100 cycles. It also responds to the harmonics of the current as readily as to the fundamental.

As a null instrument, a vibration galvanometer is often much more satisfactory than a telephone. The moving system of a vibrating galvanometer is adjusted to have the same period as that of the current to be detected, so that any harmonics in the current produce very little effect upon the deflection of the instrument. Also most vibration galvanometers have their maximum sensitiveness at low frequencies (50 to 200 cycles), though at least one form may be had which will go to frequencies as high as 3000 cycles. Since the impedance of these instruments is relatively low, they require an appreciable current to produce a deflection which can be observed. Hence in bridges where the impedance of the arms is very high, they are not very sensitive.

The vibration electrometer described in this paper was designed as a vibrating instrument having an impedance much higher than a telephone or vibration galvanometer. The need arose in connection with the measurement of some very low capacities at low frequencies. Its usefulness is limited to those cases where it is desired to detect very small currents at low frequencies. Its principal use is as a detecting instrument in a bridge having very high impedances in the arms.

The instrument is a modification of a quadrant electrometer. Instead of the quadrants there are four vertical plates, while a thin vertical vane of twice the area of a single plate corresponds to the needle of the electrometer. Two plates, separated by a narrow vertical slit, are in one plane, while opposite them in a parallel plane are the other plates. Midway between the planes is the aluminum vane, which is suspended by a bifilar suspension. This vane is maintained at constant potential by a battery, while an alternating voltage having the same period as the natural period of the vibrating system is applied to the plates. This

causes mechanical forces to be applied to the vane due to electrostatic attractions and repulsions which will set the vane in vibration. Since these forces are small, it is necessary that the damping shall be small. In addition to so designing the suspension that there is very little loss of energy in it, it is necessary to keep the instrument in a vacuum.

The form of the instrument is such that the capacities can be approximately computed. Hence it is possible to develop the mathematical theory of its behavior. This has been done and the conclusions reached have been checked by experiment. The important conclusions are as follows:

1. The frequency at which maximum deflection is obtained depends upon the potential of the vane. As the potential of the vane is increased, the frequency at which maximum deflection is obtained, is decreased.

2. The deflection for a given voltage is inversely proportional to the damping.

3. As the damping is decreased, the tuning becomes sharper.

4. The power required to give unit deflection when the applied *emf* is in resonance with the instrument decreases in the same ratio as the damping.

Experimentally it has been found that the instrument will detect a current as low as $10^{-12}$ ampere.

RADIOTELEGRAPHY.—*A direct reading instrument for measuring the logarithmic decrement and wave length of electromagnetic waves.*[1] FREDERICK A. KOLSTER, Bureau of Standards. Communicated by E. B. Rosa.

The measurement of the logarithmic decrement at radio stations is of particular importance, since the United States laws governing radio communication specify, among other things, that the logarithmic decrement per complete oscillation in the wave train emitted by the transmitter shall not exceed two-tenths. When persistent oscillations of single frequency are emitted from a radio transmitting station much more selective receiving apparatus may be employed with advantage at re-

[1] Detailed paper to appear in the Bulletin of the Bureau of Standards.

ceiving stations, permitting sharp tuning with consequent minimizing of interference caused by stations other than those with which communication is desired. It is desirable, therefore, that the logarithmic decrement, which is a measure of the decay of a train of waves, be as small as possible.

The instrument described operates in accordance with the method of Bjerknes, but the task of making careful observations and necessary calculations required by the Bjerknes formula is eliminated. An important element of the instrument is a variable condenser, the capacity of which varies in accordance with the law of geometric progression.

The simplified Bjerknes formula may be written as

$$\delta_1 + \delta_2 = \pi \frac{C_r - C}{C} = \pi \frac{\Delta C}{C}$$

where $\delta_1$ is the decrement of the circuit to be measured and $\delta_2$ the known decrement of the measuring instrument. $C_r$ is the value of capacity of the variable condenser at the point of resonance and $C$ is a slightly different capacity of such a value that the energy in the instrument at resonance is reduced to one-half.

Since the variable condenser in the instrument varies in accordance with the law of geometric progression, then for any given displacement of the condenser plates the percentage change of capacity $\frac{\Delta C}{C}$ will be constant throughout the range of motion of the condenser. It is therefore possible to attach to this condenser an accurately divided scale from which values of $\delta_1 + \delta_2$ can be read directly. Several instruments have been constructed for the Army and Navy and for the radio inspection service of the Department of Commerce.

RADIOTELEGRAPHY.—*Quantitative experiments in radiotelegraphic transmission.*[1] L. W. AUSTIN, Naval Radiotelegraphic Laboratory.

The quantitative study of long distance radiotelegraphic transmission was begun by the Navy Department in 1909–10

[1] Detailed paper to appear in the Bulletin of the Bureau of Standards.

and continued in 1912 in connection with the testing of the high power radio station at Arlington, Virginia. This station is equipped with a 100 kw. Fessenden rotary gap sending set which gives an antenna current of approximately 100 amperes at a wave length of 3800 meters. The aerial is triangular in shape and suspended between three steel towers, two of which are 450 feet in height while the third has a height of 600 feet. The capacity of the antenna is 0.01 $mf$ and the height to the center of capacity 400 feet. Short range experiments showed that the effective height of the Arlington station was only about one-half the height to the center of capacity of the antenna. This appears to be generally true of land stations and is probably due to the fact that they are not erected on sufficiently good conducting surfaces as assumed in the theory. The main scientific object of the experiments was the determination of the correctness of the Sommerfeld transmission formula

$$(1) \qquad I_R = 120\,\pi \frac{h_1 h_2 I_s}{\lambda d R} \cdot e^{\frac{-0.0019\,d}{\sqrt{\lambda}}}$$

where $h_1$ is the effective height of the sending antenna, $h_2$ the corresponding height of the receiving antenna, $I_s$ the sending antenna current, $\lambda$ the wave length, $e$ the distance between the two stations, and $R$ the effective high frequency resistance of the receiving antenna system.

The strength of the received signals was measured on the *U.S.S. Birmingham* which made a voyage to Gibraltar and return for the carrying out of the tests. The total height of the *Birmingham's* antenna was 130 feet and the height to the center of capacity 114 feet. The effective high frequency resistance was 50 ohms at 3800 meters. Signals were received by means of an electrolytic detector and their intensity was measured by the shunted telephone method which was described in the paper already cited. From the data thus obtained it was possible to determine the received antenna current $I_r$.

The table shows the results. Column five gives the experimental values as obtained from the smoothed curve of observations, and column three the values as calculated from the

Sommerfeld formula (1). Column four gives the calculated values as obtained from a semi-empirical formula (2) made up of the first term of the theoretical formula but with the absorption term replaced by the absorption term which was found to be correct in the experiments made in 1910. The values in column four are seen to be in very fair agreement with the observed values.

$$(2) \qquad I_R = 120\,\pi \frac{h_1\, h_2\, I_s}{\lambda\, d\, R} \cdot e^{\frac{-0.0015\, d}{\sqrt{\lambda}}}$$

The Sommerfeld theory takes no account of energy which may be brought to the receiving station by means of reflection or refraction in the upper atmosphere, and it is thought probable that it is this portion of the energy which produces the difference between the observed and theoretical results.

ARLINGTON RECEIVED ON THE "SALEM," FEBRUARY-MARCH, 1913

| RESISTANCE | | RECEIVED CURRENT $10^{-6}$ AMP. | | |
|---|---|---|---|---|
| Miles | Km. | Calculated | | Obs. |
| | | Eq. 1 | Eq. 2 | |
| 300 | 556 | 335.000 | 431.00 | 410.0 |
| 400 | 740 | 200.000 | 278.00 | 300.0 |
| 500 | 925 | 128.000 | 195.00 | 225.0 |
| 600 | 1110 | 85.200 | 140.00 | 160.0 |
| 800 | 1480 | 40.700 | 79.00 | 95.0 |
| 1000 | 1850 | 20.700 | 47.60 | 59.0 |
| 1200 | 2220 | 11.000 | 29.70 | 34.0 |
| 1500 | 2780 | 4.420 | 15.30 | 19.0 |
| 2000 | 3700 | 1.070 | 5.65 | 5.0 |
| 2500 | 4630 | 0.280 | 2.20 | |
| 3000 | 5560 | 0.074 | 0.84 | |

In connection with these experiments a comparison was also made between the received singals from the Fessenden spark set and those from a Poulsen arc temporarily installed at the Arlington station. It was found that, for distances up to about 1000 miles, the received antenna currents were practically the same, for the same sending antenna currents. At greater distances the arc seemed to be superior, as measured on the *Salem* and also at the U. S. Naval Radio Station at Colon, C. Z.

PHYSICAL CHEMISTRY.—*The hydration of Portland cement.*[1]

A. A. KLEIN and A. J. PHILLIPS. Bureau of Standards. Communicated by the Bureau of Standards.

The study of the hydration of Portland cement follows as a natural sequence to the study of its constitution. The latter has been determined by the work of the Geophysical Laboratory on the ternary system lime-silica-alumina, and for that portion of the ternary field in which Portland cement is situated, these compounds have been verified by the Pittsburgh laboratory of the Bureau of Standards.

In the present paper various hydration experiments were made on mono-calcium aluminate ($CaO.Al_2O_3$), 5:3 calcium aluminate ($5CaO.3Al_2O_3$), tri-calcium aluminate ($3CaO.Al_2O_3$), mono-calcium silicate ($CaO.SiO_2$), beta-orthosilicate ($2CaO.SiO_2$), gamma-orthosilicate ($2CaO.SiO_2$), tri-calcium silicate ($3CaO.SiO_2$), on lime burned at different temperatures and ground to various degrees of fineness, and on the following commercial cements, a high silica, a low silica, a high iron, and a high magnesia cement.

The tests consisted of (1) hydration on microscopic slides with water, without access of air, (2) hydration with superheated steam in a cylinder, according to the method proposed by Bied, (3) hydration in an autoclave, and (4) moulding with limited quantities of water, approximating those used in normal consistency mixes. Lime water and plaster of Paris solution were also used as hydrating media. Petrographic microscope methods were employed to determine the hydration processes and the final products.

The only crystalline product observed in the hydration of the aluminates was hydrated tri-calcium aluminate ($3CaO.Al_2O_3.xH_2O$) and this is only formed with a large excess of water. It crystallizes in hexagonal needles, plates, and spherulites, and is uniaxial positive. The refractive indices are $\epsilon = 1.552 \pm .003$ and $\omega = 1.535 \pm .003$. The 5:3 calcium aluminate and mono-calcium aluminate split off amorphous hydrated alumina and form the crystalline hydrated tri-calcium aluminate. The

[1] Detailed paper to appear in the Bulletin of the Bureau of Standards.

hydration of the aluminates commences quickly in all cases, but with restricted amounts of water the unhydrated grains become coated with the amorphous form and further hydration is more or less retarded, the amorphous form slowly changing to the crystalline form. With steam at atmospheric pressure the weakly basic aluminates do not hydrate above 110°, but those more basic absorb water up to 140°, tri-calcium aluminate containing high burned free lime absorbing water even at 175°.

The hydration of the aluminates in lime water reveals no new products, but in plaster solution, in addition to the same compounds formed with water, there is a compound observed with a formula, $3CaO.Al_2O_3.3CaSO_4.xH_2O$—tri-calcium sulpho-aluminate, usually referred to as "sulpho-aluminate" in cement literature. This compound is identical for the three aluminates and crystallizes in long prismatic needles. The double refraction is low, the character of the principal zone negative, and the extinction parallel. The indices of refraction are less than 1.48. It is biaxial positive with a large optic axial angle. Its formation is only incidental in the retardation of the initial set caused by gypsum. In the autoclave, crystals of both the sulpho-aluminate and gypsum are destroyed.

Burned lime hydrates with an excess of water develop either the crystalline or amorphous form of lime hydrate. A preponderance of the former is produced where the lime is coarse and high burned, while the formation of the amorphous form is favored by fine grinding and low burning. Crystallized lime hydrate occurs as flaky hexagonal crystals or as hexagonal prisms with excellent cleavage parallel to (0001). It is uniaxial negative and the refractive indices are $\epsilon = 1.581 \pm .002$ and $\omega = 1.559 \pm .002$. In the autoclave amorphous lime hydrate does not change to the crystalline form, but free lime may yield crystals of hydrate whose size depends upon the length of time of reaction, temperature and pressure.

The mono-calcium silicate and the gamma-orthosilicate do not hydrate, while the beta form of the latter hydrates but slightly with water after long periods. Lime water and plaster solution do not materially increase the hydration, whereas a solution of the calcium aluminate gives the maximum hydration and best

appearing test pieces. The 28 day test pieces of beta-orthosilicate and the aluminates, while, exhibiting fairly good rigidity, have by no means the strength of corresponding neat cement briquettes. The aluminates are completely hydrated, but the beta-orthosilicate shows only a comparatively slight hydration. The hydration product of the silicate is amorphous hydrated orthosilicate, there being no lime hydrate split off and no needles of hydrated mono-calcium silicate formed, as noted by others.

The tri-calcium silicate hydrates readily and quickly with all concentrations of water, the products of hydration being crystallized lime and amorphous hydrated ortho-silicate. Moulded specimens set hard in 5 hours and show no disintegration after 28 days in water. It has no favorable effect on the hydration of beta-orthosilicate. Mixtures of it and the aluminates show first the beginning of hydration of the aluminates, followed shortly by the hydration of the silicate. Moulded specimens of these are dense, hard, and strong, comparing very favorably with neat cement briquettes.

On the hydration of cement, the first constituent to react is the aluminate, with the formation of amorphous hydrated tri-calcium aluminate; with or without amorphous hydrated alumina. The sulpho-aluminate crystals are also formed and the low burned or finely ground lime hydrates. This occurs within a few hours after the cement is gauged. The next compound to hydrate is the tri-calcium silicate. This commences within 24 hours and is generally completely hydrated within 7 days. Between 7 and 28 days, the amorphous aluminate commences to crystallize and the beta-orthosilicate, the least reactive compound, begins to hydrate. The 24-hour strengths are due mainly to the hydration of the aluminates and of any fine grained, low burned lime present. The large increase in strength between 24 hours and 7 days is due mainly to the tri-calcium silicate hydration. The increase between 7 and 28 days is due to the hydration of the beta-orthosilicate. Where there is a decrease in strength during this period it is due to the hydration of very high burned free lime as in very high burned, high limed cements, or to the crystallization of the aluminates, as in high alumina

cements. The iron compounds in a cement are resistive to hydration. Iron does not form crystalline hydration products, but occurs as a rust-like material.

The initial set of cement is affected by the action of small amounts of electrolytes in retarding coagulation of the aluminate material. With a limited amount of water, such as used in normal consistency mixes, the aluminates coagulate and separate from supersaturated solutions as amorphous bodies, the rate of coagulation being affected by such small quantities of electrolyte as to nullify the possibility of the reaction being solely a chemical one.

Failure of cement in accelerated tests is due to the growth of large lime hydrate crystals. The disrupting action results from the pressure caused by growing crystals. Cements will fail in the boiling test which contain lime sufficiently fine and high burned, so that during boiling it hydrates and crystallizes. The growth of crystals is sufficient to cause disintegration. When a cement passes the boiling test but not the autoclave test, it contains lime so coarse or high burned as not to hydrate in the boiling test, but only in the autoclave, due to the high temperature and pressure employed. Some cements will pass either test only after ageing. In this case aeration with insufficient water to allow solution and crystallization causes the lime to hydrate as amorphous hydrate, and in the accelerated tests there is no crystallization and no disintegration.

The reactions when cement is subjected to the autoclave test are not abnormal. The disintegration action attributed to the crystallization of the sulpho-aluminate has been greatly exaggerated.

MINERALOGY.—*Pintadoite and uvanite, two new vanadium minerals from Utah: A preliminary note.* FRANK L. HESS and WALDEMAR T. SCHALLER, Geological Survey.

During an investigation in the fall of 1913 by Frank L. Hess and B. S. Butler of that part of the central plateau uranium-vanadium field which lies in Utah, a number of uranium and vanadium minerals hitherto undescribed or little known were

found. Some of the minerals are so mixed with impurities and are in such fine particles that mechanical separation is practically impossible and their optical characteristics can be determined only very imperfectly.

Fairly satisfactory determinations have been made of two of these minerals which have proved to be new species and it is the object of this paper to place them on record. Like most of the uranium and vanadium minerals of this field, they are highly oxidized and are hydrous. One, a green hydrous calcium vanadate, has been called *pintadoite* (peen-tä'-do-ite) from Canyon Pintado, in which it is found. The other, a hydrous uranium vanadate has been named *uvanite* (yu'-vän-ite), a word derived from the words *u*ranium and *van*adium.

*Pintadoite* forms a thin green efflorescence upon the face of cliffs of sandstone belonging to the McElmo formation, which are protected by overhanging ledges from the weather. It forms circular or rounded patches like the lichens common on rocks, and though in general of a rich dark green color, many patches are in part lighter green and contain a little yellowish or salmon colored material, which may be pascoite. The contrast with the creamy or nearly white sandstones is striking and very pretty. Being a thin efflorescence it is naturally mixed with gypsum, quartz and other minerals of the sandstone. The specimen analyzed is from the Frisco No. 2 claim, on the north side of Cañon Pintado,[1] San Juan County, about 15 miles by road, northeast of Monticello, Utah, and is the dark green material. Pintadoite has also been found at numerous other places in southeastern Utah.

The mineral shows no crystal boundaries when examined microscopically, is slightly pleochroic in yellow-green, and has a moderate to high birefringence. It dissolves slowly in cold water from which it recrystallizes in twinned, lath-shaped crystals.

The analysis, by W. T. Schaller, after deducting insoluble gangue (sandstone), soluble gypsum, and reduction to 100 per cent, is given below:

[1] Locally known as East Canyon.

*Analysis and ratios of pintadoite*

| | ANALYSIS | RATIOS | CALCULATED |
|---|---|---|---|
| CaO | 22.6 | 0.40 or 1.87 or 2 × 0.94 | 24.56 |
| $V_2O_5$ | 42.4 | 0.23 or 1.08 or 1 × 1.08 | 39.91 |
| $H_2O$ | 35.0 | 1.94 or 9.07 or 9 × 1.01 | 35.53 |
| | 100.0 | | 100.0 |

The ratios of the analysis yield the formula $2CaO.V_2O_5.9H_2O$.

*Uvanite* is a brownish-yellow hydrous uranium vanadate. Its mode of occurrence is similar to that of carnotite which it resembles in general appearance, but it has not such a clear bright yellow color. It has been found only at, and in the vicinity of, Temple Rock on the San Rafael Swell, Emery County, about 45 miles southwest of Greenriver, Utah. It occurs in rocks which are probably the equivalent of the upper part of the Dolores formation. Some masses of the new mineral are a centimeter thick, but these are rather rare. The mineral occurs in sufficient quantity to be of economic importance.

Examined microscopically, uvanite is seen to consist of very minute crystalline particles with a very high birefringence. The mineral is not soluble in water but dissolves very quickly in a solution of ammonium carbonate.

The analysis by W. T. Schaller is as follows:

*Analysis and ratios of uvanite*

| | ANALYSIS | RATIOS |
|---|---|---|
| Insoluble | 1.24 | |
| $UO_3$ | 39.60 | 0.139 |
| CaO | 1.73 | 0.031 |
| $K_2O$ | 0.30 | 0.003 |
| MgO | 0.04 | |
| $V_2O_5$ | 37.70 | 0.207 |
| $P_2O_5$ | 0.06 | 0.001 |
| $As_2O_5$ | 0.05 | |
| $H_2O$ | 18.28 | 1.106 |
| | 99.00 | |

In deducing a formula from the analysis, some uncertainty is felt in regard to the lime and potash. If these be present as ad-

mixed tyuyamunite and carnotite, then there must be present 35 per cent of these two minerals. As, however, special tests showed that both tyuyamunite and carnotite are insoluble in ammonium carbonate solution whereas the material analyzed dissolves therein with great ease and readiness, the assumption that the lime and potash present are due to these two minerals is disproved. It is not known whether the lime and potash are derived from the gangue or belong to the uvanite. The ratios deduced on the basis of either assumption are the same.

*Ratios of uvanite analysis*

| NEGLECTING $CaO + K_2O$ | COMBINING $CaO + K_2O$ WITH $UO_3$ |
|---|---|
| $UO_3$.....0.139 or 1.91 or $2 \times 0.96$ | $UO_3$.....0.150 or 2.05 or $2 \times 1.03$ |
| $V_2O_5$.....0.208 or 2.86 or $3 \times 0.95$ | $V_2O_5$.....0.208 or 2.84 or $3 \times 0.95$ |
| $H_2O$.....1.106 or 15.22 or $15 \times 1.01$ | $H_2O$.....1.106 or 15.11 or $15 \times 1.01$ |

The formula derived for uvanite is $2UO_3.3V_2O_5.15H_2O$.

Analysis of another mineral from the south side of Temple Rock, Emery County, Utah, which occurs in shaley sandstone as small greenish-yellow, glistening scales, has shown it to be like uvanite, a hydrous uranium vanadate. Further investigation is being made to determine whether it is a new species or a variety of uvanite.

Pascoite[2] has been found in small quantity on the Crescent No. 3 claim, Crescent Creek, Henry Mountains, and at a number of other places in southeastern Utah, as an efflorescence (already mentioned) and in cavities in fossil wood.

ZOOLOGY.—*The relation between recent crinoids and the temperature of their habitat.* AUSTIN H. CLARK, National Museum.

I have already discussed at considerable length[1] the relation between the recent crinoids and the temperature of the water in

[1] Une étude philosophique de la relation entre les crinoïdes actuels et la température de leur habitat. Bulletin No. 294 de l'Institut Océanographique. Monaco, 1914.

[2] Hillebrand, W. F., Merwin, H. E., and Wright, F. E. Hewettite, metahewettite and pascoite, hydrous calcium vanadates. Proc. Am. Philos. Soc., **53**: 31–54. 1914.

which they live; but there are one or two points upon which further emphasis may well be placed by presentation in a somewhat different light.

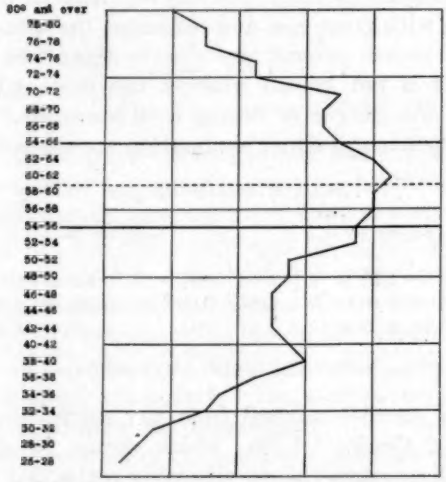


Fig. 1. The frequency of the families of recent crinoids at different temperatures.

The number of crinoid families occurring within the several divisions of 2° F. (fig. 1) which collectively make up the entire range of the class is as follows:

| | | | |
|---|---|---|---|
| 80° and over | 4 | 52°–54° | 15 |
| 78°–80° | 6 | 50°–52° | 11 |
| 76 –78 | 6 | 48°–50° | 11 |
| 74°–76° | 9 | 46°–48° | 10 |
| 72°–74° | 9 | 44°–46° | 10 |
| 70°–72° | 14 | 42°–44° | 10 |
| 68°–70° | 13 | 40°–42° | 11 |
| 66°–68° | 13 | 38°–40° | 12 |
| 64°–66° | 14 | 36°–38° | 9 |
| 62°–64° | 16 | 34°–36° | 7 |
| 60°–62° | 17 | 32°–34° | 6 |
| 58°–60° | 16 | 30°–32° | 3 |
| 56°–58° | 16 | 28°–30° | 2 |
| 54°–56° | 15 | 26°–28° | 1 |

According to the extent of their respective temperature ranges (fig. 2) the families of recent crinoids group themselves as follows:

| | | | |
|---|---|---|---|
| 1°– 6° (including families with one record only) | 4 | | |
| 6°–12° | 1 | 24°–30° | 4 |
| 12°–18° | 2 | 30°–36° | 7 |
| 18°–24° | 3 | 36°–42° | 2 |

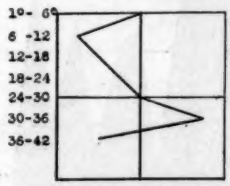


Fig. 2. Distribution of the families of recent crinoids according to their thermal ranges.

In the comatulids (fig. 3), although the Oligophreata and the Macrophreata are represented by the same number of families, six, between 50° and 55°, the families of the Macrophreata predominate at all temperatures below this, and the families of the Oligophreata at all temperatures above; but the total number of the families of the Macrophreata in excess of the total number of the families of the Oligophreata occurring below 55° is only two, while the total number of the families of the Oligophreata in excess of the total number of the families of the Macrophreata occurring above 55° is six. This indicates that the differentiation of new crinoid types is chiefly, if not entirely, confined to the warmer portions of the oceans.

There is a gradual increase in the number of the families of the Oligophreata from 30°–35°, where one only is represented, to 60°–65°, where there are six, and then a more gradual decrease as the temperature increases.

Among the families of the Macrophreata there is an increase, at first more abrupt than in the case of the Oligophreata, from 25°–30°, where one family is represented, to 50°–65°, where there are six, and then a decrease, at first much more abrupt than among the families of the Oligophreata, as the temperature increases. Thus in the Oligophreata we find the largest number of

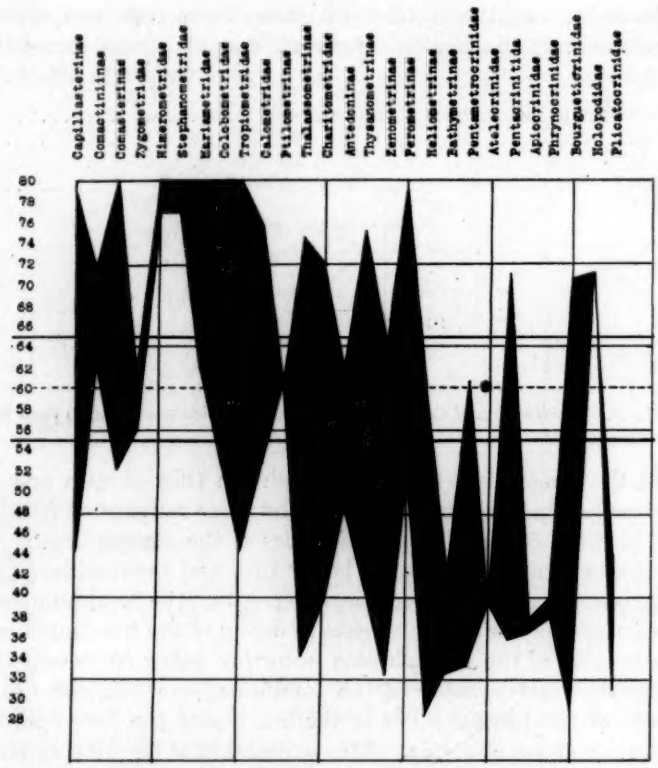


Fig. 3. Thermal distribution of the families of recent crinoids; the zone of maximum representation is between 55° and 65°, especially between 60° and 65°; it is probably within these temperatures that the very rich post-palaeozoic fauna was developed.

families between 60°–65°, in the Macrophreata between 55°–65°, the number in the case of the families of the Oligophreata diminishing gradually as the temperature increases, and the number in the case of the Macrophreata decreasing gradually as the temperature diminishes.

Examining the total for all the comatulid families, we find the largest representation between 55° and 65°, with the emphasis between 60° and 65°. The only stalked crinoids of which we have

a sufficient knowledge (the Pentacrinitida and the Bourgueticrinidae) are also found at these temperatures, while three of the others (the families Apiocrinidae, Phrynocrinidae and Plicatocrinidae) are found below, and one (Holopodidae) is known only from above.

Among the comatulids we are without sufficient data in regard to five families (Himerometridae, Stephanometridae, Tropiometridae, Ptilometrinae and Atelecrinidae); but one of these (Ptilometrinae) is actually known from this temperature, while the four others are without doubt found here, if we may judge from the mean temperature of the sea at the depths at which they are known to live. At least all except four, and with little doubt all, of the comatulid families are found between 55° and 65°, and not only these, but also the two dominant families of the stalked crinoids (Pentacrinitida and Bourgueticrinidae). Thus it appears that the range of temperature between 55° and 65° (12.78° and 18.33°C.) represents the temperature most suitable for the recent crinoids.

There are certain very interesting attributes of the crinoids which are found between the temperature limits of 55° and 65°; they are all of medium size, none being very large and none very small, and they are all conservative in their characters, with never a large number of arms—usually ten only. This would appear to indicate that the range of temperature between 55° and 65° represents the temperature physiologically most suitable for the crinoids, a temperature which tends to maintain a phylogenetical conservatism and to suppress any tendency toward the extreme type of development characteristic of the crinoids of the warm water, as well as that characteristic of the crinoids of the cold water.

So far as can be seen, it is with recent species found between these temperatures that the fossil crinoids best agree, and thus the suggestion may be made that it was principally, if not entirely, within this temperature range that the crinoids of the post-palaeozoic fauna, which was characterized by a very great development of the present dominant order, the Articulata, were developed.

# ABSTRACTS

**Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.**

METEOROLOGY.—*The total radiation received on a horizontal surface from the sun and sky at Mount Weather, Va.* HERBERT H. KIMBALL. Monthly Weather Review, **42**: 474–487. August, 1914.

At this station a Marvin pyrheliometer was employed to measure the intensity of direct solar radiation at normal incidence, and a Callendar horizontal recording pyrheliometer for measuring the total radiation received on a horizontal surface from the sun and sky. By employing a screen to eclipse the sun at intervals throughout the day, the Callendar pyrheliometer was also utilized to measure the total radiation from the sky alone. The bright receiving grids of this pyrheliometer are selectively absorptive of radiation of different wave lengths and it was therefore necessary to standardize the instrument for measurements of radiation of different degrees of blueness, varying from the color of sunlight to that of skylight. This was accomplished by comparing measurements by Callendar and Marvin pyrheliometers of the intensity of solar radiation transmitted by color screens.

The summary of measurements made between May, 1912, and September, 1914, inclusive, shows that during this period with the clearest sky the total radiation per square centimeter of horizontal surface varied from 250 calories per day on December 20 to 765 calories on June 10. On March 20 it was 605 calories, and on September 20, 515 calories. In general, the radiation received on a clear day during the half-year, December 21 to June 20, averaged about 8 per per cent more than that received during the remaining half year.

The average daily radiation in summer, including rainy and cloudy as well as clear days, was about 68 per cent of that received on the clearest days, and in winter about 63 per cent.

At noon, with a clear sky, the total radiation per minute per square centimeter of horizontal surface varied from 0.77 calorie in December

to 1.55 calories in June. When clouds were near the sun but did not obscure it these rates were increased momentarily by as much as 0.15 calorie. For the period September, 1907, to September, 1914, the maximum intensity of direct solar radiation at normal incidence at noon varied from 1.37 calories in January to 1.50 calories in May and September.

The measurements show that at mid-day in summer about 18 per cent of the total radiation received on a horizontal surface was diffuse sky radiation. With a hazy sky about one-third of the total daily radiation was received in this way, as compared with one-tenth on a very clear day.

The measurements also show that at noon, on a clear mid-summer day, each square yard of horizontal surface at this station received heat energy at the rate of about 1 kilowatt, and that the total received from sunrise to sunset was equivalent to about 5 kilowatt-hours. From the middle of March to the end of August, on the clearest days, the total energy received was equivalent to 4 kilowatt-hours, or more.

H. H. K.

GEODESY.—*Primary triangulation on the one hundred and fourth meridian, and on the thirty-ninth parallel in Colorado, Utah, and Nevada.* WILLIAM BOWIE. Special Publication No. 19. Coast and Geodetic Survey. Pp. 163. 1914.

This volume contains the geographic positions and the descriptions of about 600 primary triangulation stations, which are located along the 104th meridian of longitude in Colorado, Wyoming, the Dakotas, and Montana, and along the 39th parallel of latitude in the states of Colorado, Utah, and Nevada.

The field work of the 39th parallel triangulation was completed in the late nineties, and a report on that work appeared in 1899 as Coast and Geodetic Survey Special Publication No. 4. Since that date a standard datum for all connected triangulation in this country was adopted and called the United States Standard Datum. In 1913, when this datum was adopted by Mexico and Canada, its name was changed to the North American Datum. It is not identical with that on which the Transcontinental triangulation was originally based, hence the necessity of publishing the new positions in Special Publication No. 19.

The field work on the 104th meridian triangulation was done during one season of about six months by two observing parties. As this arc is 720 miles in length, the rate of progress for each party was about 60 miles per month.

There is given an account of the remeasurement of the El Paso Base line in Colorado, which was first measured with the "Secondary Base Bars" in 1872. The remeasuring was done with 50-meter invar base tapes. The difference between the two measurements is one part is about 59,000. As the base ends were very substantially marked, when the base was established, it is believed that the discrepancy is not due to any shifting of the marks but that it is the result of an error in the first measurement, probably caused by the inability to secure the actual temperature of the metal rods of the bars by means of mercurial thermometers mounted near the rods.

Three new bases were measured on the 104th meridian with invar tapes and the probable error of each base is smaller than one part in one million. Nearly all of the observing for horizontal angles in the main scheme was done at night, the pointings being made on acetylene lamps posted at the distant stations. These lamps were of sufficient power to be seen easily over the longest lines of the scheme—about 70 miles.

The introduction of additional precise leveling elevations in the trigonometric leveling net made a readjustment of the net necessary. In consequence, a number of mountains are given elevations which differ from the elevations given in Special Publication No. 4. Except in a few cases in the vicinity of Pike's Peak, the new elevations are lower than the older ones. The changes in California and in western Nevada and in central Colorado are small, being only one foot for Mt. Elbert and Mt. Ouray in Colorado, and two feet for Mt. Grant in Nevada. The maximum change comes in Utah; Pilot Peak, for instance, having its elevation changed by 16 feet.

A discussion of the errors of triangulation indicates that when the observations are made during the day and in the afternoon, triangulation running north and south tends to deviate in azimuth towards the west. Under similar conditions an east and west arc tends to deviate towards the south. This systematic error is not present to any noticeable extent when all the observations are made at night. It is stated that the error is probably due to some effect of unequal heating of the theodolite. To minimize or overcome any such effect, the theodolite now in use on primary triangulation is fitted with a nickel-iron circle which has a much lower coefficient of expansion than that of the original circle. No data are yet available as to the accuracy obtained with a new circle.

W. B.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE WASHINGTON ACADEMY OF SCIENCES

The 92d meeting of the Washington Academy of Sciences was a delightful all day, May 16, 1914, excursion of about 150 members to Annapolis and the United States Naval Academy. Through the kindness of the Navy Department and the Superintendent of the Naval Academy, Capt. W. S. Fullam, many courtesies, including a trip up the Severn and return on torpedo boats, were extended to the visiting guests. The weather was ideal, and the excursion, under the management of the Committee on Meetings, in every way a success.

The 93d meeting of the Washington Academy of Sciences, a business meeting, with President White in the chair and attended by twenty members, was held in the Cosmos Club on May 28, 1914.

The revised by-laws, as proposed on May 5, 1914, were adopted, with but one amendment, namely, that the life membership fee shall be $75, instead of, as formerly, $100.

At the suggestion of the corresponding secretary, Dr. Burgess, it was agreed that the memorial volumes of the Royal Society of London, after being kept on exhibition for a time at the Cosmos Club, be given to Dr. L. O. Howard, who was the Academy's official representative at the meetings in question.

Dr. G. R. Olshausen, of the Bureau of Standards, was elected to resident membership.

W. J. HUMPHREYS, *Recording Secretary.*

## THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 743d meeting was held on October 10, 1914, at the Cosmos Club, Vice President Eichelberger in the chair; 25 persons present.

Mr. H. H. KIMBALL read a paper on *Measurements of the total radiation received on a horizontal surface from the Sun and sky.* From records at Mt. Weather since 1912 of the Callendar horizontal recording pyrheliometer, it has been found that the total radiation per square centimeter of horizontal surface, with the clearest sky, varies from 250 calories per day on December 20, to 765 calories on June 10. The average daily radiation in summer is about 68 per cent of that received on clear days, and in winter it is about 63 per cent. The maximum solar radiation at normal incidence varies from 1.37 calories per minute per square centimeter in January, to 1.50 calories in May and September. The total radiation on a horizontal surface with a clear sky varies

from 0.77 calories per minute in December to 1.55 calories in June. When clouds are near the Sun, but do not obscure it, the momentary rates are increased by about 0.15 calorie per minute. The diffuse sky radiation received on a horizontal surface at noon averages about 25 per cent of that received on the same surface from the Sun. On a clear summer day it amounts to from one-eighth to one-third of the total radiation. The paper was illustrated by lantern slides. The communication was discussed by Messrs. BOWIE and HUMPHREYS.

Mr. F. E. FOWLE then presented an illustrated paper on *Atmospheric transparency and Avogadro's constant.* A brief summary of this paper was published in this Journal, **4**: 529–530. 1914. The paper was discussed by Messrs. HUMPHREYS, BOWIE, and EICHELBERGER.

The 744th meeting was held on October 24, 1914, at the Cosmos Club, President Fischer in the chair; 22 persons present.

Mr. W. W. COBLENTZ presented a paper on *A comparison of stellar radiometers and radiometric measurements on stars.* It was shown there is but little difference in the radiation sensitivity of stellar thermocouples constructed of bismuth-platinum or of bismuth-bismuth + tin alloy. An improved method of maintaining vacuum by means of metallic calcium was used. Measurements were made on 112 celestial bodies, including 105 stars, quantitatively on stars to the 5.3 magnitude and qualitatively to the 6.7 magnitude. It was found that red stars emit from 2 to 3 times as much total radiation as blue stars of the same photometric magnitude. Measurements were made on the transmission of radiation of stars through an absorption cell of water; these showed that, of the total radiation emitted, the blue stars have about 2 times as much radiation as the yellow stars and about 3 times as much as the red stars. A stellar thermocouple in comparison with a bolometer was found more sensitive. The investigation showed that the sensitivity required to do much successful work in stellar spectral energy curves would be 100 times that of the apparatus used, which was such that when combined with a 3-foot reflecting telescope a deflection of 1 mm. would have resulted when exposed to a candle 53 miles distant. The paper was discussed by Messrs. SWANN and WENNER.

Mr. H. L. CURTIS then spoke on *Insulating properties of solid dielectrics with special reference to surface films.* A summary of this paper appeared in this Journal, **4**: 492, 1914. The paper was discussed by Messrs. C. A. BRIGGS, BURGESS, SWANN, and STILLMAN.

The 745th meeting was held on November 7, 1914, at the Cosmos Club, President Fischer in the chair; 49 persons present.

By invitation, Mr. J. JOHNSTON spoke on *Some effects of high pressure.* Thorough investigation of the effects producible by high pressure will yield information of very great value in its bearing upon many fundamental problems of physics and chemistry. For example, it would seem that we are much more likely to ascertain precisely what happens when a crystal melts by studying this process through a wide

range of pressure. Although comparatively little systematic investigation of this domain has yet been made, several conclusions seem now to be justified; the more important are as follows: Increase of pressure raises the melting point (with but two known exceptions—bismuth and ice 1), the change produced being progressively smaller for each successive pressure increment; but there is no reason for believing that there is either a maximum melting point (as had been postulated by Tammann) or a critical end-point solid-liquid. Change of pressure may either raise or lower a transformation temperature (solid → solid) or a solubility; this implies that change of pressure may alter the number and nature of the substances crystallizing out from a cooling solution containing several components. Increase of pressure produces a decrease of electrical resistance of all the pure metals investigated (bismuth excepted), but increases the resistance of the alloys; the change of resistance of manganin or therlo is the most convenient means of measuring high pressures accurately. Change of pressure displaces the position of equilibrium of a chemical reaction, especially in reactions involving a vapor phase, since it has such a marked effect upon the concentration of the vapor. The communication was discussed by Messrs. BUCKINGHAM, SWANN, BOWIE, and HUMPHREYS.

Mr. L. J. BRIGGS then spoke on *The Australian meeting of the British Association for the Advancement of Science.* The meeting was made possible through the generosity of the Australian Commonwealth, which placed at the disposal of the British Association a fund to defray in part the over-sea expenses of members and guests. Meetings were held at Perth, Melbourne, Adelaide, Sydney, and Brisbane, the capitals of the five states of the Commonwealth. The scientific meetings were limited to Melbourne and Sydney. Numerous excursions were arranged at each place. Free transportation was provided on all the railroads, and the over-sea members were entertained in each of the cities. Of the many interesting papers presented before the physical section, there was mentioned in particular the address of the President of the section, Professor TROUTON, on *Absorption and adsorption;* Mr. C. G. ABBOT'S paper on *The variability of the Sun;* Sir ERNEST RUTHERFORD'S paper on *Gamma rays;* and Mr. MOSELEY'S paper on *High frequency spectra.*

J. A. FLEMING, *Secretary.*

## BOTANICAL SOCIETY OF WASHINGTON

The ninety-eighth regular meeting of the Botanical Society of Washington was held October 6, 1914, in the Cosmos Club. Forty members and two guests were present. The following scientific program was given:

P. H. DORSETT, *The botanical garden of Rio de Janeiro, Brazil* (with lantern).

W. F. WIGHT, *Andean origin of the cultivated potato* (with lantern and specimens).

Both papers are to be published elsewhere.

The fourteenth annual meeting of the Botanical Society of Washington was held at 1.30 p.m., October 23, 1914. The customary reports were presented and approved and the following officers were elected for the ensuing year: Dr. R. H. TRUE, President; Mr. G. N. COLLINS, Vice President; Prof. C. E. CHAMBLISS, Recording Secretary; Dr. PERLEY SPAULDING, Corresponding Secretary; Mr. H. C. GORE, Treasurer, and Mr. W. E. SAFFORD, Vice President to the Washington Academy of Sciences.

The ninety-ninth regular meeting of the Botanical Society of Washington was held November 3, 1914 in the Cosmos Club. Forty-nine members and three guests were present. Mr. WILSON POPENOE was unanimously elected to membership. The scientific program was:

PAUL POPENOE, *The date palm in antiquity* (with lantern). The speaker referred particularly to the influence of the date palm on the religion of the Semitic peoples. Prized for the food and drink it furnished, it was revered because of the mystery of sex emphasized by its monoeciousness, and became identified with the primitive mother goddess of fertility. A sacred palm in a garden at Eridu, near the mouth of the Euphrates river, is thought by many investigators to be the origin of the Tree of Life of the Garden of Eden, described in Genesis. The culture of the palm was thoroughly known at a very early period, the Babylonian inscriptions giving reason to believe that it was more skillful 1900 years B.C. than it is in that region 1900 years A.D.

W. E. SAFFORD, *The economic plants of ancient Peru.* This paper was based upon collections and observations made by the speaker while cruising along the Peruvian and Chilian coast, in 1887, and while acting as Commissioner for the World's Columbian Exposition to Peru and Bolivia, in 1891 to 1893. Prehistoric graves were opened at Caldera, Iquique, Arica, the Rimac valley, Ancon, Chimbote, Truxillo, and the vicinity of Payta. The material obtained is mainly in the Field Columbian Museum at Chicago and the United States National Museum. In addition to objects of ethnological interest many articles were found illustrating the ethnobotany of ancient Peru. Not only were seeds, seed-pods, dried fruits, leaves, and tubers found, but beautiful representations of many of the food plants in terra-cotta, in the form of funeral vases, were discovered in graves near the coast, especially at Chimbote and Truxillo. Among these were a number not included in Wittmack's list published in Reis and Stuebel's great work "Das Todtenfeld von Ancon." Beautiful models in terra-cotta of the tubers of *Solanum tuberosum* were found, also of the fruits of *Solanum muricatum* and *Lucuma obovaia*, and most interesting of all the almond-like kernels of *Caryocar amygdaliforme* R. & P., easily distinguished by their protruding recurved embryo. Another interesting object was a terra-cotta vase representing the roots of the yahutia (*Xanthosoma* sp.). The collections include specimens of *Phaseolus vulgaris* and *Phaseolus lunatus*, a gourd full of peanuts (*Arachis hypogaea*) and models of the same on terra-cotta vases; mandioca roots and models of the latter; quantities of maize and models of the same on funeral vases; bags of coca leaves

(*Erythroxylum Coca*), and specimens of raw cotton, dark brown, light brown, and white, together with spindles with cotton yarn upon them; looms with half-woven fabrics, and textiles of beautiful and intricate designs. Among the most interesting of the funeral vases were forms representing the corn god of ancient Peru, a monster with protruding tusks, surrounded by ears of maize; and the god of agriculture, represented with a stalk of maize in one hand and a stalk of mandioca in the other, with a cluster of roots at the base very much like those of a dahlia.

This paper was illustrated by numerous slides, principally of objects collected by the speaker and now in the collection of the Field Columbian Museum.

PERLEY SPAULDING, *Corresponding Secretary.*

## THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

At the 475th regular meeting of the Society, held October 21, in the Public Library, Dr. D. S. LAMB, of the Army Medical Museum, delivered an address on *Sanitation in ancient civilizations.* In the usage of the speaker the word ancient was specifically applied to the period before the fall of the Roman Empire. The beginning of the historic period for different nations, he said, varies much; for Egypt, about 11,000 B.C.; for the American nations, within the Christian era. But the character of all the beginnings was probably much the same: human necessities, life, health, food, clothing, shelter, differed but little, except as influenced by climate or geographical position. The need of sanitation was especially shown by the histories of epidemics; for instance, the black death of the fourteenth century destroyed, it is said, about 25,000,000 persons.

Pure water was one of the first necessities. Man must have availed himself at first of the use of springs, lakes, and streams; and when these were not available, he dug a well; later, to have the water still more accessible, he built a cistern. And when many families had congregated together, he built an aqueduct to bring the water to the town or city and to distribute it to the individuals. Old artesian wells are found in Asia Minor, Persia, China, Egypt, Algeria, and even the Desert of Sahara. There were aqueducts in Palestine; one was built by Hezekiah about 700 B.C. The earliest form of aqueduct in Greece was at Cos. Rome had at one time 19 aqueducts; 14 of these were large and together had a total length of 359 miles, 55 of which was on arches, sometimes 100 feet high. Some of these are still in use. Most however fell into decay or were destroyed by hostile armies. In olden times when the king of Persia travelled he had the water boiled before drinking it. Aqueducts have been found in Mexico, Guatemala, and Peru, antedating the arrival of Columbus.

As for the disposal of waste, among the Hebrews it was buried or burned. There is no account of drainage among the Greeks. The Romans built great *cloacae* or sewers, that carried the storm water and

refuse into the Tiber. Several of these are still in use. At one time the sewers were cleaned out at a cost of a million dollars; it was necessary to divert the course of seven so-called rivers to do it. The disposal of the dead varied much in different nations. After a battle it was usual either to bury in large pits or trenches or to burn the bodies. The opening of such pits or trenches, as well as the opening of church vaults and old burial grounds, sometimes caused sickness and even death. The Egyptians buried the dead after embalming them. Infants, however, were often buried beneath the habitation. In India the dead were generally cremated. The Parsees placed their dead on gratings in towers, for the vultures to eat; the bones were afterwards gathered up. Among the Massagatae, says Herodotus, when a man became old, he was sacrificed and eaten. In Greece the dead were buried near the houses of the living; coffins of stone were used. The Romans cremated the dead after about 450 B.C. until the spread of Christianity, when for several centuries it was the custom to place the dead in the catacombs beneath the city of Rome. The Hebrews always buried outside the camp or city. The story of the burial of Jesus Christ is that the body was wrapped in linen with spices about 100 pounds in weight and buried in a tomb in a garden on Mount Calvary. The ancient Mexicans cremated the dead. Indian mounds in the United States contain bodies of the dead.

The desire to bathe is probably as old as man himself. The Lacedemonians are said to have devised the hot air bath. The Scythians took a sweat bath. Soap was mentioned by Pliny about 25 A.D. and was said to have been brought from Germany. The Hebrews were required by religious regulations to be clean in person, clothing, and houses. In Egypt, when Alexandria was taken by the Caliph Omar in 646, there were 4000 baths, and the 700,000 books of the great library were burned to heat these baths. The Romans had many public baths, free to all. The bath of Caracalla was a mile in circumference and accommodated 2000 persons. The Greeks bathed daily.

Contagious diseases afflicted the ancients even more than the moderns. The Hebrews especially attempted to get rid of leprosy by segregating the lepers. Circumcision was common among the Egyptians, the Ethiopians and peoples in the Pacific Islands, Asia Minor, Persia, Arabia, and eastern and western Africa. Among the Hebrews the custom was a religious ceremonial. The Egyptians believed that diseases usually were contracted through food and drink, and therefore they tabooed some articles of food. Among the Greeks the Pythagoreans had rules relating to what they ate or drank as well as to their exercises. The Hebrews had many rules of diet that had the force of religious injunctions; especially as to meat, the animal had to be slaughtered in a certain way and with much attention to detail.

DANIEL FOLKMAR, *Secretary.*

XC